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DESIGN AND PERFORMANCE ANALYSIS OF A NOVEL SWITCHED FITH ACCESS NETWORK

LAU PENG WAH

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DESIGN AND PERFORMANCE ANALYSIS OF A NOVEL SWITCHED FTTH ACCESS NETWORK

By

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November 2002

Chairman: **Elok Robert Tee, Ph.D.**

Faculty: **Computer Science and Information Technology**

Over these years, rapid development of bandwidth consuming applications has pushed the existing network infrastructure to the limit particularly in the access layer. There has been many development of high speed protocols to meet the demands but the existing physical medium, which consists of copper-based network, do not have the capabilities to support these protocols. Thus, the problem still exist and as time goes by, more and more demand and the use of high bandwidth applications have really clogged the access line. This problem is referred to as the access network bottleneck problem.

In addressing the access network bottleneck problem, Fiber-To-The-Home (FTTH) technology has been introduced in the local loop, taking advantage of optical fibers huge bandwidth. However, there is still one obstacle, which has been generally overlooked, which is, providing protection to the access line. The fiber optics access mainly consists of a single fiber running upstream and a single fiber running downstream. If a protection path were to be created, the network provider would have to

lay another 2 fibers on the network. This would increase deployment costs and also costs for the subscribers. Thus, a new way of providing fault tolerance to the system has to be introduced, by taking costs consideration and also efficiency in deploying the solution.

In this thesis, a novel scheme for providing fault tolerance to the FTTH system is introduced. Also, various classes of traffic are defined. All these classes of traffics can logically represent different applications based on their Quality of Service (QoS) requirements. These traffics are run on the switched FTTH access network model. The survival of the network is studied by terminating the supporting OLT unit one after another and observing the packet delay, packet loss ratio, the buffer occupancy and also the throughput of the switch. Results show that for different traffic classes, the number of supportable ONUs can exceed the standard value of the FSAN recommendations, which are 32 units per OLT. For example, for a two OLT access network, the maximum recommended supportable ONU units are 64 units whereas in the proposed system, up to a maximum of 128 ONU units can be supported under normal conditions; where there are no OLT failures or fiber breaks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

REKABENTUK DAN ANALISA PENEMUAN ASLI RANGKAIAN AKSES FTTH YANG MEMPUNYAI KEUPAYAAN BERSIUS

Oleh

LAU PENG WAH

November 2002

Pengerusi: **Elok Robert Tee, Ph.D.**

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Sejak kebelakangan ini, pembangunan aplikasi yang memerlukan banyak keperluan rangkaian telah menyebabkan jaringan rangkaian infrastruktur yang sekian ada tidak dapat menampung keperluan sebanyak ini terutamanya di rangkaian jaringan akses. Memang tidak dinafikan bahawa banyak protokol-protokol yang bekelajuan tinggi telah direka khas untuk mengatasi masalah ini tetapi medium fizikal seperti kabel rangkaian, tidak dapat menyokong protokol-protokol ini. Dengan ini, masalah tersebut masih ada dan dari masa ke masa, perkembangan pesat aplikasi yang memerlukan banyak "bandwidth" akan mengakibatkan saluran rangkaian akses menjadi lebih sesak lagi.

Dalam menangani masalah ini, teknologi Fiber-To-The-Home (FTTH) telah diperkenalkan ke bahagian rangkaian akses. Gentian optik mempunyai kebolehan untuk membawa banyak maklumat. Dengan semua teknologi ini, masih terdapat satu masalah

yang sering dipandang remeh iaitu memberi perlindungan kepada saluran rangkaian utama yang membawa maklumat. Saluran rangkaian akses gentian optik terdiri daraipada satu gentian optik yang membawa maklumat ke "upstream" dan satu lagi gentian optik yang membawa maklumat ke "downstream". Jikalau ingin memberi perlindungan kepada saluran rangkaian gentian optik, 2 lagi gentian optic tambahan perlu diletakkan ke dalam rangkaian tersebut. Ini akan meningkatkan kos instalasi dan juga kos untuk menggunakan perkhidmatan tersebut juga akan naik. Oleh itu, satu cara baru untuk memberi perlindungan kepada rangkaian akses tersebut perlu diperkenalkan dengan memberi penekanan kepada kos dan juga efisiensy kaedah tersebut.

Di dalam tesis ini, satu penemuan asli kaedah memberi perlindungan kepada rangkaian FTTH telah diperkenalkan. Di samping itu, pelbagai jenis kelas trafik telah diperkenalkan. Kesemua jenis kelas trafik tersebut boleh mewakili pelbagai jenis aplikasi bergantung kepada servis quality (QoS) mereka. Trafik-trafik ini digunakan dalam simulasi rangkaian FTTH tersebut. Keupayaan tahanan rangkaian tersebut dianalisakan dengan mensimulasikan kerosakan OLT-OLT dalam rangkaian tersebut. Parameter-parameter seperti kelambatan paket, nisbah kerosakan paket, bilangan paket yang menduduki bufer suis yang digunakan dan juga throughput suis tersebut. Dalam keputusan simulasi yang didapati, bilangan ONU yang dapat disokong oleh rangkaian tersebut adalah melebihi bilangan ONU yang direkomendasikan oleh FSAN, iaitu hanya 32 unit untuk satu OLT. Dengan menggunakan kaedah kami, dua OLT dapat menyokong sejumlah 128 unit ONU berbanding dengan 64 unit ONU oleh FSAN.

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November 2002

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I certify that an Examination Committee met on 1st November 2002 to conduct the final examination of Lau Peng Wah on his Master of Science thesis entitled "Design and Performance Analysis of a Novel Switched FTTH Access Network" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. The Members of the Examiniation Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

LAU PENG WAH

Date: 19/11/2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

ABR	Available Bit Rate
ADSL	Asymmetrical Digital Subscriber Line
APON	Asynchronous Transfer Mode Passive Optical Network
AS	Autonomous System
ATM	Asynchronous Transfer Mode
BAF	Broadband Access Facilities
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CNT	Counter
CO	Central Office
CPE	Customer Premises Equipment
CTD	Cell Transfer Delay
DLC	Digital Loop Carrier
DP	Delay Priority
EDD	Earliest Due Date
EDF	Earliest Deadline First
EFM	Ethernet in the First Mile
ETSI	European Telecommunications Standards Institute
FCFS	First Come First Served
FIFD	First In First Dropped
FIFO	First In First Out

FITL	Fiber-In-The-Loop
FSAN	Full Service Access Network
FTP	File Transfer Protocol
FTTB	Fiber-To-The-Building
FTTC	Fiber-To-The-Curb
FTTCab	Fiber-To-The-Cabinet
FTTH	Fiber-To-The-Home
HDTV	High Definition Television
HOL	Head of Line
HOL-PJ	Head of Line with Priority Jumps
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
ITU	International Telecommunications Union
LIFD	Last In First Dropped
LP	Loss Priority
LW	Loss_Weight
MAC	Medium Access Control
MPEG	Moving Picture Expert Group
MPLS	Multi Protocol Label Switching
MTBF	Mean Time Before Failure
MTTR	Mean Time To Repair
MTU	Maximum Transmission Unit
MUX	Multiplexer

NMS	Network Management System
nrt-VBR	non real time-Variable Bit Rate
OCF	Oldest Customer First
OLT	Optical Line Termination
ONU	Optical Network Unit
ORU	Optical Repeater Unit
OSI	Open System Interconnection
PBS	Partial Buffer Sharing
PDU	Protocol Data Unit
PON	Passive Optical Network
POP	Point-of-Presence
POTS	Plain Old Telephone Service
PS	Pushout Scheme
QoS	Quality of Service
RACE	Research and development for Advanced Communications in Europe
rt-VBR	real time-Variable Bit Rate
SCM	Sub-Carrier Modulation
SCP	Self Calibrating Pushout
SDH	Synchronous Digital Hierarchy
SDK	Software Development Kit
SMTP	Simple Mail Transfer Protocol
S-PON	Super Passive Optical Network

STM	Synchronous Transfer Mode
STP	Spanning Tree Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TH	Threshold
TV	Television
UBR	Unspecified Bit Rate
UTP	Unshielded Twisted Pair
VBR	Variable Bit Rate
VoD	Video-on-Demand
WDM	Wavelength Division Multiplexing
WWW	World Wide Web
xDSL	x-Digital Subscriber Line